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USE OF SLIME WASTE FROM NUCLEAR POWER PLANTS IN A SYSTEM FOR CHEMICAL PURIFICATION OF WATER

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The possibility of using slime waste generated in chemical purification of NPP sewage instead of lime is investigated. The main properties of the products obtained under different temperatures and different rates of heat treatment are determined.

Thermal and nuclear power plants generate a significant quantity of slime waste, which represents a serious problem in their operation. The large quantities of waste, the contamination of the ambient environment by disperse slime particles after drying, and the impossibility of fully recycling this waste for practical purposes stimulate the development of a close-cycle water purification process. This is especially topical for nuclear power plants (NPP) usually located near large water reservoirs. Such waste is generated in liming of water to reduce its hardness and decrease the corrosion of the heat-generating machinery. The amount of dry slime residue may reach 4000 tons per year. As a consequence, slime is accumulated, which requires new slime-settling pits.

Several ways for solving this problems have been proposed, including the use of drinking water. The proposed method has significant disadvantages, since its application contributes to a discharge of non-purified mineralized water into the ambient medium and increases the intensity of corrosion processes in heat pipelines.

There are several technologies making it possible to use the slime waste generated in chemical purification of water in the production of household and sanitaryware and in road construction. They are all protected by patents and have passed laboratory and semi-industrial testing. The difficulty of implementing these technologies consists in the impossibility of ensuring a required constant moisture in the chemical purification slime and its full utilization, for instance, in producing ceramic facing tiles or faience articles (RF patent No. 2065424) [1].

From our point of view, the most promising line is using slime as a material for production of lime to be used in the system for chemical purification of water. All prerequisites for solving this problem are present, of which the most important is a sufficient constancy of the slime residue compo-

sition with respect to the content of the main oxides: CaO, MgO, SiO₂, and Al₂O₃. The quantity of these oxides depends mostly on the composition of the initial water. A study of Don River waters established that their chemical composition fluctuates insignificantly (Table 1).

The utilization of the slime liquid generated at the nuclear power plants, in particular at the Volgodonsk NPP, is of special interest, since it should satisfy increased requirements related to radiation activity.

It can be seen from Table 1 that the slime contains up to 90% (estimated based on the chemical composition) calcium and magnesium carbonates. The x-ray analysis of dry slime resulting from chemical water purification and of natural carbonate rock (limestone) indicated (Fig. 1) that the interplanar distances (0.302, 0.249, 0.228, 0.209, 0.191, 0.187, and 0.160 nm) correspond to calcite. The diffraction patterns of slime and lime reveal an identical CaCO₃ content, which makes it possible to attribute slime to carbonate rocks used in the production of air-hardening lime.

It is known that natural carbonate materials are widely used for the production of air-hardening lime, which consists in decarbonization of CaCO₃ and MgCO₃ at a firing tempera-

TABLE 1

Power plant	Mass content in slime, %					
	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	calcination loss
Voronezh steam power plant	4.7	2.0	4.8	45.3	2.8	40.9
Novocherkassk steam power plant	1.4	1.4	2.6	47.6	4.2	41.8
Rostov steam power plant-2	4.8	1.2	2.5	49.7	0.3	43.6
Volgodonsk nuclear power plant	5.1	2.4	1.7	45.1	4.6	40.3

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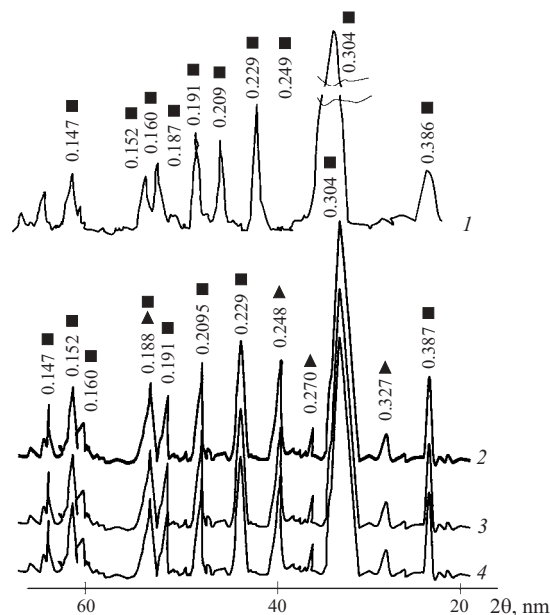


Fig. 1. X-ray diffraction patterns of limestone (1), water from the Rostov power plant-2 (2), Volgodonsk NPP (3), and Novochoerkassk power plant (4): ■ calcite; ▲ aragonite.

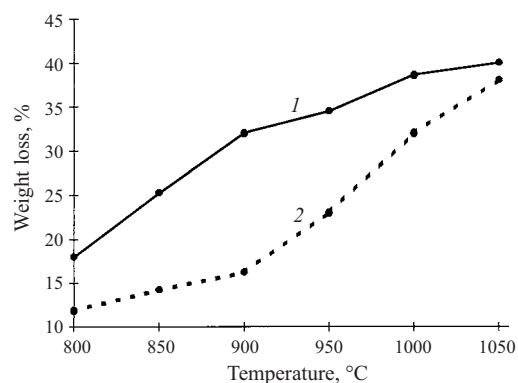


Fig. 2. Weight loss in firing of slime (1) and limestone (2).

ture of 910–960°C for the chemical purity grade of calcium carbonate and up to 1130–1280°C for other materials [2].

A differential thermal analysis was carried out to determine the temperature of decarbonization of the materials considered. It is established that the decarbonization of slime resulting from chemical purification of water proceeds within a temperature interval of 850–950°C, and the decarbonization of limestone proceeds at 1000–1100°C. These processes are accompanied by a weight loss. According to the studies performed (Fig. 2), the weight loss increment in the slime from the Volgodonsk NPP fired at 800, 900, 1000, and 1100°C with a 1-h exposure in the furnace is faster, which points to the high activity of the slime waste.

During fast drying of the liquid slime, a defective fine-crystalline structure is formed, which is represented both by calcium carbonates and calcium hydrocarbonates that have a tendency to a faster decomposition.

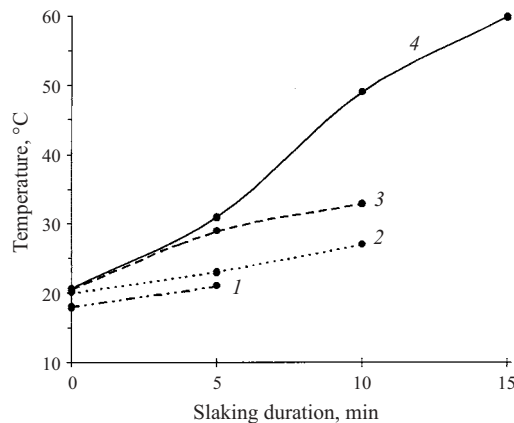


Fig. 3. The rate and temperature of slaking lime produced from slime at heat treatment temperatures of 800 (1), 900 (2), 1000 (3), and 1050°C (4).

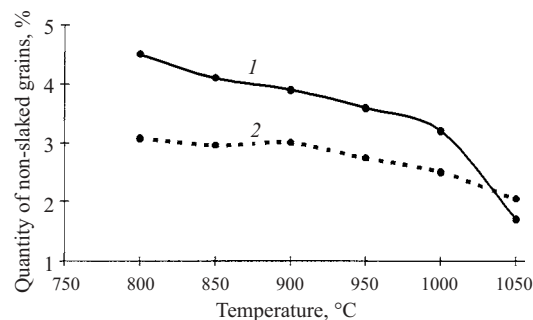


Fig. 4. Dependence of the quantity of non-slaked grains on the heat treatment temperature of lime based on slime (1) and limestone (2).

The maximum temperature in the roasting kilns producing unslaked lime CaO from natural limestone is 100–200°C higher than the theoretical temperature of decomposition of these materials. The specific properties of the slime make it possible to roast it at lower temperatures.

The technology of lime regeneration from calciferous slime is economically expedient only under certain condition: a constant content of CaCO_3 (up to 90%) and a slime moisture not higher than 30%. Otherwise the activity of the resulting lime will not be greater than 30% [3].

We have proposed a procedure for fast thermal treatment of slime in a modernized tower. Liquid slime of 45–65% moisture from a slime tank is pumped with a membrane pump under a pressure of 2.3–3.0 MPa to a spray atomizer in the top part of the tower. The dispersed lime drops are dried due to heat generated in gas combustion in the burners installed around the perimeter of the tower and due to the gas flow emitted from the decarbonization zone. Due to a well extended surface of the drops, the drying lasts 20–30 sec.

The dried powder has a grain size of 0.2–0.5 mm; it sinks and gets into the decarbonization zone. The firing temperature in this zone is maintained around 1000–1100°C using additional gas burners. The roasting of the powder in

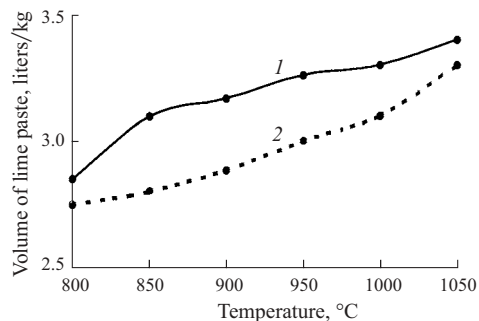


Fig. 5. Dependence of the yield of lime paste on the heat treatment temperature of lime based on slime (1) and limestone (2).

the decarbonizing unit lasts not more than 10 min, which ensures the required degree of decarbonizing. The lime is discharged from beneath the drying kiln onto a conveyor belt. The plant is provided with a draft that intensely removes the emerging gaseous CO_2 from the system. After thermal treatment the lime can be used for preparing lime milk.

To determine the properties of the lime produced by a fast heat treatment, technological testing of lime obtained from slime and from limestone was carried out according to

GOST 9178-77 in the laboratory conditions (Figs. 3 – 5). It is established that the optimum temperature for fast heat treatment of slime and limestone is 1050°C. The properties of lime produced at this temperature meet the standard requirements. The lime produced from slime can be attributed to the category of medium-slaking lime with a slaking temperature around 60°C. Since the yield of lime paste is one of the main construction parameters of lime, the considered lime based on slime can be attributed to fat lime (Fig. 5)

Thus, the waste slime generated in chemical water purification at a nuclear power plant can be used to produce active lime and recycled in a continuous process.

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